ROBERT K. MORROW, JR.
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Education:

Degree	Year	School
PhD	1988	Purdue University, Indiana
MSEE	1982	Stanford University, California
BSEE	1974	United States Air Force Academy, Colorado

PhD Dissertation:

"Bit-to-Bit Error Dependence in Direct-Sequence Spread-Spectrum Multiple-Access Packet Radio Systems," School of Electrical Engineering, Purdue University, West Lafayette, IN, May 1988. Dissertation introduces an improved Gaussian approximation for calculating bit error rates in direct-sequence spread-spectrum systems. This approximation is much more accurate than other Gaussian approximations, and also can be used to account for the error dependence from bit-to-bit due to constant chip and carrier phase offsets between desired and interfering signals during packet transmission.

Recent Employment History:

Jul 1994 - Present: President, Morrow Technical Services. Primary business is teaching short courses and consulting on wireless systems for industry. Developed and taught extensive short courses in Wi-Fi, Bluetooth, ZigBee, Z-Wave, and cellular systems (including GSM, CDMA, and LTE). Authored books *Bluetooth Operation and Use* and *Wireless Network Coexistence*, published by McGraw-Hill. Developed prototype of a wireless telemetry network and successfully demonstrated it to a test equipment manufacturer. Taught course in Electrical Engineering Technology for Purdue University. Commissioned by the *Encyclopædia Britannica* to author article on Telecommunications Networks. Wireless communications consultant for government and industry. Reviewer of technical papers for the Institute of Electrical and Electronics Engineers (IEEE). Expert witness on wireless technologies. Manufacturer and distributor of collimation enhancement tools for telescopes.

Jul 1992 - Jun 1994: Deputy Head, Department of Electrical and Computer Engineering, Graduate School of Engineering, Air Force Institute of Technology, Wright-Patterson AFB, OH. Deputy head of the largest department in the Graduate School of Engineering. Supervised over 50 military and civilian personnel in accomplishing the department's research and teaching mission. Taught graduate courses in satellite and spread-spectrum communications, digital and analog communications, and digital logic design. Directed environmental compliance effort for the solid state research laboratory. Reviewed technical papers for the IEEE.

Aug 1990 - Jun 1992: Director of Research, Office of the Dean, United States Air Force Academy, CO. Directed the entire faculty and cadet research program at the Academy, involving about 300 faculty and 400 cadet students. Increased student participation by more than 40%. Established research programs with the National Aeronautics and Space Administration, the Department of Energy, and the National Security Agency. Supervised the implementation of technology transfer through five Cooperative Research and Development Agreements between the Academy and civilian agencies. Earned Letter of Appreciation from the Secretary of the Air Force. Personally selected by the National Institute of Standards and Technology to review proposals submitted by industry for the Advanced Technology Program. Reviewed technical papers for the IEEE. Awarded a United States Patent on a spread-spectrum packet radio system.

Aug 1990 - Jun 1992: Member, USAF Chief Scientist Group. Group consists of senior officials who advise unit commanders throughout the Air Force on critical technology issues.

Aug 1989 - Aug 1990: Chairman, Armed Forces Communications and Electronics Association (AFCEA) Military Space Symposium, United States Air Force Academy, CO. Nationwide symposium attracts over 300 military and civilian participants yearly to discuss military applications in space. Key speaker was the Deputy Secretary of Defense.

Jul 1988 - Aug 1990: Chief, Computer Engineering Division, Department of Electrical Engineering, United States Air Force Academy, CO. Taught six electrical engineering courses in computer systems, communications, linear systems, and design. Responsible for overall administration of one-third of Department of Electrical Engineering curriculum, instruction, and resources. Implemented major laboratory renovation and improved curriculum accordingly. Taught a short course on data communications to military agencies in Alaska and Germany. During academic leave of absence, produced baseline transition plan for major communication system for Air Force Space Command.

Honors and Awards:

Instructor Achievement Award, Interop, Las Vegas, 2004, for top-rated instructor.

Meritorious Service Award, Armed Forces Communications and Electronics Association, 1991.

Best Paper, Purdue Electrical Engineering and Industrial Institute: 1986.

Company Grade Officer of the Year, Department of Electrical Engineering, United States Air Force Academy: 1983.

Company Grade Officer of the Quarter, Department of Electrical Engineering, United States Air Force Academy: Jul-Sep 1983.

Company Grade Officer of the Quarter, Department of Electrical Engineering, United States Air Force Academy: Jan-Mar 1983.

R. E. Thomas award for Outstanding Educator, Department of Electrical Engineering, United States Air Force Academy: 1983-84.

USAF Meritorious Service Medals: 1994, 1992, 1985.

USAF Commendation Medals: 1981, 1977.

Distinguished Graduate, Pilot Instructor Training: 1979 (Top 10%).

Distinguished Graduate, Undergraduate Pilot Training: 1975 (Top 10%)

Honor graduate, United States Air Force Academy: 1974 (Top 15%).

Society Memberships:

Senior Member, Institute of Electrical and Electronics Engineers (IEEE).

Life Member, Air Force Association (AFA).

Life Member, Armed Forces Communications and Electronics Association (AFCEA).

Life Member, American Radio Relay League (ARRL).

Selected Publications:

Book Contributions

R. K. Morrow, Jr., *Wireless Network Coexistence,* McGraw-Hill, published July 2004.

R. K. Morrow, Jr., *Bluetooth Operation and Use,* McGraw-Hill, published June 2002.

R. K. Morrow, Jr., "A Peek Into Pandora's Box: Direct Sequence vs. Frequency Hopped Spread Spectrum" Chapter 28 in *Wireless Personal Communications, Emerging Technologies for Enhanced Communications,* William H Tranter, Theodore S. Rappaport, Brian D. Woerner, and Jeffrey H. Reed, eds., Kluwer Academic Publishers, 1999.

R. K. Morrow, Jr., "CDMA Bit Error Rate Calculations: Which Approach Works Best?" Chapter 7 in *Wireless Personal Communications, Improving Capacity, Services, and Reliability,* Theodore S. Rappaport, Brian D. Woerner, Jeffrey H. Reed, and William H Tranter, eds., Kluwer Academic Publishers, 1998.

R. K. Morrow, Jr., "Spread-Spectrum Packet Radio Using Narrowband Headers," Chapter 7 in *Wireless Personal Communications, Advances in Coverage and Capacity,* Jeffrey H. Reed, Theodore S. Rappaport, and Brian D. Woerner, eds., Kluwer Academic Publishers, 1997.

R. K. Morrow, Jr., "Telecommunications Networks," part of article "Telecommunications Systems," *Encyclopædia Britannica*, 1997 edition.

Journal Papers (Refereed)

R. K. Morrow, Jr., "Accurate CDMA BER Calculations with Low Computational Complexity," *IEEE Transactions on Communications*, November 1998. Paper describes procedures to calculate bit error probabilities in a direct sequence code division multiple access radio system when signals employ either random or deterministic spreading sequences and under various chip and phase offset situations. All calculations have a computational complexity of order 1.

R. K. Morrow, Jr. and J. S. Lehnert, "Packet Throughput in Slotted ALOHA DS/SSMA Radio Systems with Random Signature Sequences," *IEEE Transactions on Communications*, July 1992. Paper shows how an improved Gaussian approximation for calculating spread-spectrum bit error rates can be used to develop packet throughput figures for an accurate assessment of communication network performance.

J. B. McCormack, R. K. Morrow, Jr., et al, "The Complimentary Roles of Laboratory Notebooks and Laboratory Reports," *IEEE Transactions on Education*, February 1991. Paper examines the synergistic relationship between the notebook and subsequent report in a student's laboratory courses, and applies the lessons learned to professional research.

R. K. Morrow, Jr. and J. S. Lehnert, "Bit-to-Bit Error Dependence in Slotted DS/SSMA Packet Radio Systems with Random Signature Sequences," *IEEE Transactions on Communications*, October 1989. Paper introduces to the international research community an improved Gaussian approximation for calculating bit error rates in direct-sequence spread-spectrum systems. This approximation is much more accurate than other Gaussian approximations, and also can be used to account for the error dependence from bit-to-bit due to constant chip and carrier phase offsets between desired and interfering signals during packet transmission.

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Industry Journal Papers

Robert Morrow, "Wi-Fi-Fo-Fum," *Science*, 23 May 2008. Compares the Wi-Fi and WiMAX wireless technologies for data access.

R. K. Morrow, Jr., and Theodore S. Rappaport, "Getting In," *Wireless Review,* March 1, 2000. Article presents a method to analyze RF signal penetration through various building obstructions and describes how to evaluate signal levels from outside macrocells and their interference to indoor picocells.

R. K. Morrow, Jr., "Propagation Models for Indoor Wireless Network Engineering," *Microwave Product Digest,* April 1999. Article evaluates the various RF propagation models available to engineers and how they measure up in real-world wireless system deployment.

R. K. Morrow, Jr., "Site-Specific Engineering for Indoor Wireless Communications," *Applied Microwave & Wireless,* March 1999. Article describes how site-specific RF propagation modeling can improve the chance that an indoor wireless system will operate as expected.

R. K. Morrow, Jr., "Extending Receive Coverage for the IC-02 and IC-04," Ham Radio Magazine, July 1986. Article describes a simple modification to two popular commercial hand-held transceivers that enables them to receive public service frequencies in addition to transmitting and receiving frequencies assigned to Amateur Radio.

R. K. Morrow, Jr., "Hunt the Auto-Fox," 73 Magazine, August 1985. Article describes the design and construction of a Morse Code identification system that attaches to any transmitter, allowing it to be used in radio direction finding exercises while meeting all federal identification requirements.

R. K. Morrow, Jr., "Ntty Grtty RTTY," 73 Magazine, September 1984. Article describes the design and construction of an interface unit connecting the ZX-81 computer to a radio transceiver to enable the transmission and reception of Baudot teletype codes.

R. K. Morrow, Jr., "The Simple Simplex Autopatch," Ham Radio Magazine, January 1983. Article describes the design and construction of a device that connects between a transceiver and the telephone lines, allowing someone with another transceiver to employ it as a radiotelephone.

R. K. Morrow, Jr., "WARC and LF on the TR-7," QST, July 1982. Article describes the design and construction of a plug-in module for the Drake TR-7 transceiver to give it transceive capability on three new Amateur Radio bands, as well as very low frequency (VLF) receive.

R. K. Morrow, Jr., "Repeater Kerchunk Eliminator," Ham Radio Magazine, October 1977. Article describes the design and construction of a module for use in a commercial transceiver to prevent signals of a short duration from reaching the audio circuit.

R. K. Morrow, Jr., "Try These IC-230 Mods," 73 Magazine, May 1977. Article describes the design and construction of several modifications to the ICOM IC-230 transceiver, giving it variable transmitter power, automatic transmit offset selection, and doubling the number of channels it can tune.

Selected Conference Papers and Presentations

R. K. Morrow, Jr., "Indoor Wireless Signal Propagation and Range Estimation," invited tutorial, Networld Interop Symposium, Las Vegas NV, May 3, 2006.

R. K. Morrow, Jr., "Indoor Wireless Signal Propagation and Range Estimation," invited tutorial, Networld Interop Symposium, Las Vegas NV, May 4, 2005.

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R. K. Morrow, Jr., "Indoor Wireless Signal Propagation and Range Estimation," invited tutorial, Networld Interop Symposium, Las Vegas NV, May 12, 2004.

R. K. Morrow, Jr., "Bluetooth: for Wireless Personal Area Networking," invited tutorial, Networld Interop Symposium, Las Vegas NV, April 30, 2003.

R. K. Morrow, Jr., "Indoor Wireless Propagation: How Far Will it Go?" invited tutorial, Networld Interop Symposium, Las Vegas NV, May 1, 2003.

R. K. Morrow, Jr., "Bluetooth Signal Propagation and Range," Bluetooth Developer's Conference, San Jose CA, December 11, 2002.

R. K. Morrow, Jr., "Bluetooth and 802.11: Can They Live Together?" invited tutorial, IEEE International Microwave Symposium, Seattle WA, June 2, 2002.

R. K. Morrow, Jr., "Bluetooth Applications: Thinking Out of the Box," invited tutorial, IEEE International Microwave Symposium, Seattle WA, June 2, 2002.

R. K. Morrow, Jr., "Bluetooth: Operation & Use," invited tutorial, Networld Interop Symposium, Las Vegas NV, May 10, 2002.

R. K. Morrow, Jr., "Fundamentals of Short Range Wireless," invited tutorial, Wireless Symposium, San Jose, CA, February 12-16, 2001.

R. K. Morrow, Jr., "Wireless Networking Fundamentals," invited paper, Wireless Symposium, San Jose, CA, February 12-16, 2001.

R. K. Morrow, Jr., "Introduction to Bluetooth," invited tutorial, Wireless Symposium, San Jose, CA, February 12-16, 2001.

R. K. Morrow, Jr., "Low-Cost Implementation of Wireless Telemetry," Embedded Systems Conference, Chicago, IL, February 28 – March 2, 2000.

R. K. Morrow, Jr., "Short Range Wireless and Bluetooth," invited tutorial, Eighth Annual Wireless Symposium, San Jose, CA, February 21-25, 2000.

R. K. Morrow, Jr., "Fundamentals of Wireless Networking," invited paper, Eighth Annual Wireless Symposium, San Jose, CA, February 21-25, 2000.

R. K. Morrow, Jr., "Short Range and Low Power Device Design Issues and Techniques," invited tutorial, Eighth Annual Wireless Symposium, San Jose, CA, February 21-25, 2000.

R. K. Morrow, Jr., "A Peek into Pandora's Box: Direct Sequence vs. Frequency Hopped Spread Spectrum," Proceedings of the 8th Annual Symposium on Wireless Personal Communications, Virginia Tech, Blacksburg, VA, June 10-12, 1998.

R. K. Morrow, Jr., "CDMA Bit Error Calculations: Which Approach Works Best?," Proceedings of the 7th Annual Symposium on Wireless Personal Communications, Virginia Tech, Blacksburg, VA, June 11-13, 1997.

R. K. Morrow, Jr., "Spread-Spectrum Packet Radio Using Narrowband Headers," Proceedings of the 6th Annual Symposium on Wireless Personal Communications, Virginia Tech, Blacksburg, VA, June 5-7, 1996.

R. K. Morrow, Jr., "A Narrowband/Wideband Packet Radio System," Proceedings of the 1994 Tactical Communications Conference (AFCEA/DARPA), Fort Wayne, IN, May 10-12, 1994.

J. B. McCormack, R. K. Morrow, Jr., et al, "The Complimentary Roles of Laboratory Notebooks and Laboratory Reports," 1990 American Society for Engineering Education (ASEE) Annual Conference, Toronto, Ontario, Canada, June 24–28, 1990.

R. K. Morrow, Jr. and J. S. Lehnert, "The Effect of Gaussian Approximations and Bit-to-Bit Error Dependence on Packet Throughput in DS/SSMA Radio Systems," Proceedings of the 1990 Tactical Communications Conference (AFCEA/DARPA), Fort Wayne, IN, April 24-26, 1990.

R. K. Morrow, Jr. and J. S. Lehnert, "An Improved Gaussian Approximation to the Bit Error Probability in Binary Direct-Sequence Spread-Spectrum Multiple-Access Communication Systems," Proceedings of the 1988 Tactical Communications Conference (AFCEA/DARPA), Fort Wayne, IN, May 3-5, 1988.

R. K. Morrow, Jr. and J. S. Lehnert, "Bit-to-Bit Error Dependence in Slotted DS/SSMA Packet Systems with Random Signature Sequences," Proceedings of the 1988 Conference on Information Sciences and Systems, Princeton University, March 16-18, 1988.

R. K. Morrow, Jr., "The USAF Academy Cadet Summer Research Program," Proceedings of the 15th Annual Frontiers-in-Education Conference, Golden, CO, October 19-22, 1985.

Patents:

R. K. Morrow, Jr., "A Narrowband/Wideband Packet Data Communication System," US patent 5,022,046 dated June 4, 1991. Patent describes a packet radio network that combines the advantages of several different spread-spectrum signaling methods to produce an efficient packet radio network with easier implementation and improved performance over many other systems.